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New species and new reports of *Diorygma* (lichenized *Ascomycotina, Graphidaceae*) from India

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Abstract — Four species in the lichen genus *Diorygma* including the two new species *D. longilirellatum, D. saxicola* and two new combinations *Diorygma rufosporum* and *D. subalbatum* are recognized in India.

Keywords — lichenized fungi, ascomycetes, taxonomy

Introduction

The lichen genus *Diorygma* Eschw., with thirty three species throughout the world (Kalb et al. 2004, Archer 2006, 2007, Archer & Elix 2008, Cáceres 2007, Sharma & Makhija 2009), is widely distributed in tropical to subtropical regions.

In a recent account of the genus *Diorygma* (Kalb et al. 2004), four species, namely *D. junghuhnii* (Mont. & Bosch) Kalb et al., *D. megasporum* Kalb et al., *D. pruinosum,* and *D. tuberculosum* (Stirt.) Kalb et al., were reported from India. In addition, *D. hieroglyphicum* was reported from the Andaman Islands. Four additional new species, namely *Diorygma dealbatum* B.O. Sharma & Makhija, *D. inaequale* B.O. Sharma & Makhija, *D. manipurense* B.O. Sharma & Makhija, and *D. verrucirimosum* B.O. Sharma & Makhija, with divergent exciples and muriform, hyaline ascospores, and with norstictic and salazinic acids, have been recorded (Sharma & Makhija 2009).

Further studies in the family *Graphidaceae* from India have resulted in the recognition of four additional species, including two new species and two new combinations, which are described below.

Materials and methods

In the present work chemical data was obtained by the standard methods of TLC (Culberson & Kristinsson 1970, White & James 1985) using solvent systems benzene-dioxane-acetic acid (180:45:5), hexane-ethyl ether-formic acid

(130:80:20) and toluene-ethyl acetate-formic acid (139:83:8). The specimens have been deposited in the Ajrekar Mycological Herbarium (AMH).

Key to the species

1a. Ascospores 1/ascus or rarely 2/ascus 2

1b. Ascospores more than 1/ascus 6

2a. Protocetraric acid present (ascocarps 1–3 mm long; disc grayish, pruinose; exciple non-carbonized or carbonization sometimes restricted to the basal corners; asci 1-spored; ascospores muriform, 147–160 × 33.6–42 µm; protocetraric acid present). ..... ***D. pruinosum***

2b. Protocetraric acid absent 3

3a. Ascospores more than 200 µm long (ascocarps 1–3 mm long; disc yellowish to brownish, pruinose; asci 1-spored; ascospores muriform, (135–) 168–205 × 54–96 µm, with a 5–7.5 µm, thick gelatinous sheath; constictic and stictic acids present). ..... ***D. rufosporum***

3b. Ascospores less than 200 µm long 4

4a. Norstictic acid absent (Ascocarps whitish, 0.4–3 mm long; disc whitish, 0.2–0.4 mm broad; asci 1-spored; ascospores muriform, 126–130 × 37–42 µm, with a 5–15 µm thick sheath; constictic, stictic, acids present) ..... ***D. hieroglyphicum***

4b. Norstisctic acid present 5

5a. Thallus greenish grey with red tinge; ascocarps long flexuous, branched, up to 9 mm long, immersed; disc pale brown; ascospores muriform, 105–113 × 34–42 µm; norstictic acid present ..... ***D. longilirellatum***

5b. Thallus creamy white, grayish; ascocarps 0.4–4 mm long, round to irregular; disc 0.2–0.3 mm broad, pale brown; asci 1(–2)-spored; ascospores 84–134.4 × 29.4–42 µm, with a 2.3–5 µm sheath; constictic acid (trace), norstictic, and stictic acid (major) present ..... ***D. junghuhnii***

6a. Thallus saxicolous; ascocarps crowded, immersed to slightly emergent; disc narrow to slightly broad, 0.2-0.3 mm broad in section; exciple indistinctly striate; asci 1–6-spored; ascospores 143–172 × 29.4–33.6 µm; constictic, nonstictic (trace) and stictic acids present ..... ***D. saxicola***

6b. Thallus corticolous, ashy white; ascocarps white, straight to curved, branched, 0.5–2.5 mm long, immersed; disc 0.3–0.6 mm broad; exciple convergent to divergent, indistinctly striate; asci 1–8-spored; ascospores 75–145 × 24–33.6 µm; norstictic, stictic, acids present. ..... ***D. subalbatum***

Diorygma hieroglyphicum (Pers.) Staiger & Kalb

Symb. Bot. Upsal. 34(1): 151 (2004). FIGURE 1

≡ *Opegrapha hieroglyphica* Pers., Ann. Wetterauischen Ges. Gesammte Narurk. 2: 16 (1811).

= *Graphis particeps* Nyl., Bull. Soc. Linn. Normandie Sér. 2, 7:177 (1874).

≡ *Graphina particeps* (Nyl.) Müll. Arg., Flora 65: 386, 1882.

Type of *Graphis particeps*: Andaman Islands, in coll. Hook. Thoms. 2264 (H-NYL **holotype**)

Thallus greenish with whitish tinge, smooth, often with fine cracks, 120–140 µm thick; surface continuous; delimited by thin blackish brown hypothallus; pseudocortex not visible; medulla and algal layer not differentiated, studded with crystals. Ascocarps off white to concolourous with the thallus, immersed to semi-emergent, short, flexuous, branched, narrow, curved, irregular, 1–4 mm long, ends acute to obtuse. Disc broad, brown, 0.2–0.4 broad, pruinose. Exciple non-carbonized, poorly developed, yellowish brown laterally and basally not striate. Epithecium distinctly developed, 12–15 µm high, brown consisting of intermingled anastomosing, hyaline paraphysis tips. Hymenium hyaline, 90–110 µm tall, not inspersed. Asci 1-spored. Ascospores muriform, hyaline, peripheral and central spore locules of equal size, 80–131 × 42–52 µm, with a 5–15 µm thick sheath, I+ violet.

Chemistry—Stictic, constictic and norstictic acids present.

Additional specimens examined—North Andaman, Diglipur Range, Sitapur, moist deciduous forest, *P.G. Patwardhan & M.B. Nagarkar* 86.229, South Andaman, Port Mount, *M.B. Nagarkar & P.G. Patwardhan*, 85.9; Maharashtra State, Pune district, Khandala, *P.G. Patwardhan,* 70.1a; Sindhudurg district, on the way to Vaibhavwadi to Phonda, *B.C. Behera & V.A. Mantri,* 00.326:AMH.

Remarks—*Diorygma hieroglyphicum* is a pantropical species that has been reported from Africa, the Philippines, New Caledonia, Papua New Guinea, and the Andaman Islands (Kalb et al. 2004) and from Australia (Archer 2006). Additional specimens are here reported from India where it occurs in the semi-evergreen forest of Maharashtra.

Diorygma junghuhnii (Mont. & Bosch) Kalb, Staiger & Elix
Symb. Bot. Upsal. 34(1): 157 (2004). Figure 2

≡ *Ustalia junghuhnii* Mont. & Bosch,, Plantae Junghuhniaenae Fasc. IV, Lugduni-Batavorum: 477 (1855).

Thallus creamy white, grayish, pale gray, 80–90 µm thick; rough, uneven, cracked, often along the lirellae; delimited by black hypothallus; pseudocortex not visible; medulla not distinct. Ascocarps yellowish to whitish in colour, numerous, round to long, broad, 0.4–4 mm long, 0.2–0.4 mm broad, more or less flexuous, branched, immersed to slightly raised,. Disc brownish grey covered by yellowish cream pruina, 0.2–0.3 mm broad. Exciple divergent, non-carbonized, orange yellow at the base. Epithecium distinct, yellowish brown. Hymenium 63–125 µm tall, not inspersed, I+ blue. Asci 1–2-spored. Ascospores hyaline, muriform, 84–134 × 29–42 µm, with a 2.5–5 µm thick sheath, peripheral and central spore locules of equal size, I+ violet.

Chemistry—Constictic (trace), norstictic acids present.

Additional specimens examined—Assam, Gauhati to Shillong road, 10 km from Gauhati, near Buratti, *P.G. Patwardhan & M.B. Nagarkar,* 77.684; Meghalaya, 20 km near Shillong on Gauhati to Shillong road, above Nowpong near Barapani, *P.G. Patwardhan & M.B. Nagarkar*, 77.711; Shillong, Moflong, *M.B. Nagarkar*, 78.464; Kerala, Near Chinnar, 60 km from Munnar, Munnar-Udumalpet, *P.G. Patwardhan & M.B. Nagarkar,* 85.1734, 85.1735, 85.1736; Tamil Nadu, Kalghatgi to Yellapatii, *M.B. Nagarkar & A.V. Prabhu*, 77.12; Marayoor, Anamalai hills, *P.G. Patwardhan & M.B. Nagarkar*, 76.439; Anamalai hills, Marayoor, *C.R. Kulkarni,* 76.460:AMH

Remarks—*Diorygma junghuhnii* is a widely distributed tropical species that has been reported from Africa, South America, the Philippines, and Australia (Kalb et al. 2004); in India it was collected from the sacred forest in Moflong of Meghalaya at an altitude of 1300 m and in the evergreen forests of Kerala and Tamil Nadu.

Diorygma longilirellatum B.O. Sharma & Makhija, **sp. nov.** Figure 3

MycoBank MB 513336

Similis Diorygma erythrellum *sed ascis monosporiis differt.*

Etymology: From the Latin *longus*, long, and *lirellatus,* lirelline; a reference to the long lirelline ascocarps.

Holotypus–India, West Bengal, 3 km from Sikkim diversion on Gauhati Road, 23.10.1977, *P.G. Patwardhan & M.B. Nagarkar*, 77.655: AMH.

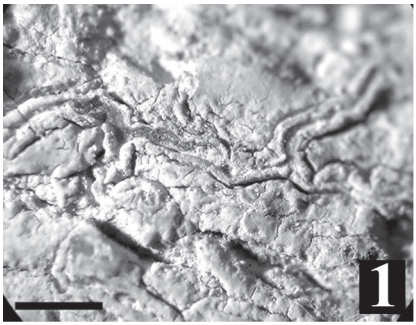
Thallus greenish grey with red tinge, red granular particles seen on the surface of the thallus, 60–70 µm thick; surface more or less smooth, uneven or partly with small warts, delimited by blackish brown hypothallus, notched at the ends; pseudocortex not seen; medulla compact, well developed, not separated from the algal layer, often with many crystals. Ascocarps long flexuous, branched, curved, up to 9 mm long, immersed to more or less raised above the surface of the thallus. Disc slightly open, pale brown, covered by pruina. Exciple convergent to divergent, non-carbonized, poorly developed. Epithecium distinctly developed 20–25 µm high consisting of brownish, paraphyses tips. Hymenium 63–100 µm tall, not inspersed, I+ blue. Asci 1-spored. Ascospores hyaline, muriform, peripheral and central spore locules of equal size, 105–113 × 33–42 µm, I+ violet.

Chemistry—Norstictic acid present.

Remarks—*Diorygma longilirellatum* is characterized by the long lirellae, asci with a single ascospores, and norstictic acid in the thallus.

Many species of this genus contain norstictic acid but the new species, *Diorygma longilirellatum,* differs from these species as follows: *D. circumfusum* has transversely septate ascospores, *D. erythrellum* (Mont. & Bosch) Kalb et al.

Figures 1–5 (right) Habit. 1. *D. hieroglyphicum.* 2. *D. junghuhnii.* 3. *D. junghuhni* (with broad, dark disc). 4. *D. longilirellatum* (Holotype). 5. *D. pruinosum.* 6. *D. rufosporum.* 7. *D. saxicola* (Holotype). 8. *D. subalbatum* Bar = 1 mm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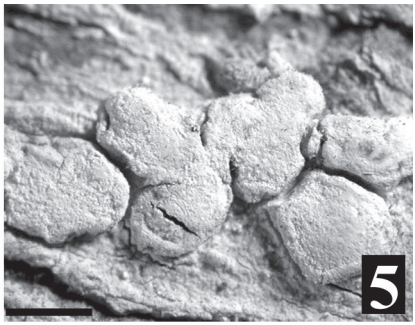
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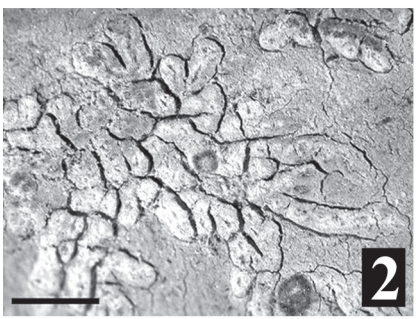
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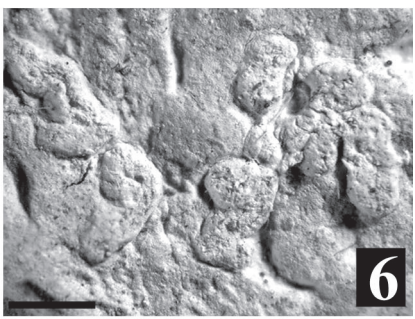
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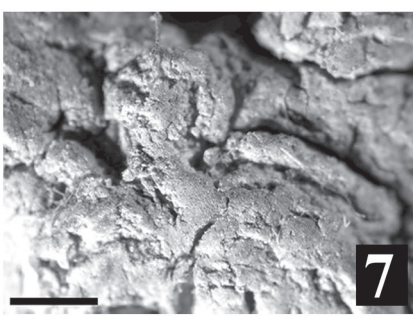
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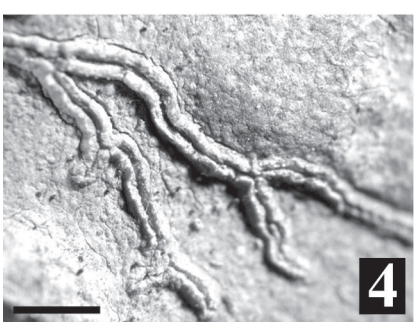
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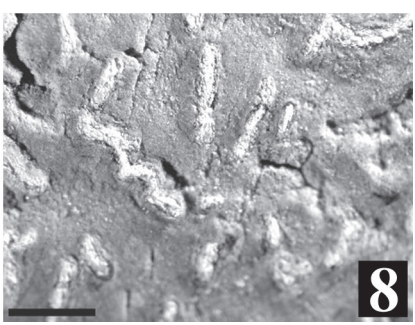
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has 8-spored asci, *D. junghuhnii* has con-norstictic acid, *D. macgregorii* (Vain.) Kalb et al. has larger ascospores and a different chemistry, *D. pachygraphum* (Nyl.) Kalb et al. and *D. soozanum* (Zahlbr.) M. Nakan. & Kashiw. have larger ascospores of 170–250 µm and 110–145 µm long respectively, with peripheral cells distinctly smaller than the central ones, and *D. tinctorium* Eschw. and *D. tuberculosum* also have peripheral cells distinctly smaller than the central ones.

Diorygma pruinosum (Eschw.) Kalb, Staiger & Elix

Symb. Bot. Ups. 34(1): 166 (2004). FIGURE 4

≡ *Leiogramma pruinosum* Eschw., In Martius, Icones selectae plantarum cryptogamicarum. Fasc. I: 12 tab. 7, Fig. 3 (1828).

Thallus whitish green, thin, easily flaking off from the substratum, 70–100 µm thick; surface smooth, not farinose, slightly cracked; pseudocortex not seen; medulla filled with crystals. Ascocarps concolorous with the thallus, circular, oval, short curved, 1–3 mm long, ends round, simple. Disc grayish, broad covered by white pruina, 0.5–1 mm broad. Exciple divergent, non-carbonized to carbonization sometimes restricted to the basal corners. Epithecium distinctly developed, brown, consisting of brownish reticulately branched paraphysis tips. Hymenium hyaline, 121–150 µm tall, not inspersed, I+ blue. Asci 1-spored. Ascospores hyaline, muriform, peripheral and central spore locules of equal size, 147–160 × 34–42 µm, I+ violet.

CHEMISTRY—Protocetraric acid.

ADDITIONAL SPECIMENS EXAMINED—Andaman Islands, South Andaman, Nilambur, Forest Guest House, Baratang, *M.B. Nagarkar & P.G. Patwardhan*, 85.313, 85.335, 85.343, 85.373, 85.425, 85.429, 86.146; Port Mount, *M.B. Nagarkar & P.G. Patwardhan*, 85.11, 85.25, 85.30, 85.31, 85.476, 85.499; Assam, Maniknagar, *P.G. Patwardhan & M.B. Nagarkar*, 77.1196, 77.1215; Nigwal-Bibra Road, *M.B. Nagarkar*, 78.309; Kerala, Kumly Kerala Road, *C.R. Kulkarni & P.D. Badhe*, 73.2257; Tamil Nadu, Wynad forest, *P.D. Badhe & C.R. Kulkarni*, 73.2308: AMH

REMARKS—*Diorygma pruinosum* is a pantropical species found in Africa, South America, Indonesia, Papua New Guinea, New Caledonia, and Australia (Kalb et al. 2004). In addition, a single specimen was reported from Assam, collected in 1879. Further specimens from India are reported here together with specimens from the Andaman Islands. The species is characterized by a whitish green thallus, a densely pruinose disc, and the presence of protocetraric acid. In India the species is found in the Andaman Islands, Assam, Kerala and Tamil Nadu.

Diorygma rufosporum (Patw. & C. R. Kulk.) B.O. Sharma & Makhija, **comb. nov.**

MYCOBANK MB 513338 FIGURE 5

≡ *Phaeographina rufospora* Patw. & C.R. Kulk., Ind. J. Bot. 2(2): 138 (1979).

Holotypus–India, Karnataka, South Canara, Shimoga Dist., Kalkoppa forest, 15.12.1974, *C.R. Kulkarni*, 74.2914:AMH (!).

Thallus grayish white, powdery, smooth, finely cracked, hypothallus white. Ascocarps concolorous with the thallus, 1–3 mm long, emergent, branched. Disc yellowish to brownish, flat, wide, pruinose. Exciple divergent, non-carbonized. Epithecium distinctly developed, brown, consisting of brownish reticulately branched paraphyses tips. Hymenium hyaline, 125–200 µm tall, not inspersed, I+ blue. Asci 1-spored. Ascospores hyaline, muriform, peripheral and central spore locules of equal size, (135–) 168–205 × 54–96 µm with 5–7.5 µm thick sheath, I+ violet.

Chemistry—Constictic (major) and stictic (major) acids present.

Additional specimens examined—Maharashtra State, Amboli, Amboli to Sawantwadi Road, *M.B. Nagarkar,* 74.2355; Karnataka State, North Canara, Khanapur to Londha road, Gangavati, *P.G. Patwardhan,* 74.2404, 74.2405, 74.2420, 74.2421; Londha, 74.2528, 74.2544, 74.2545, 74.2585, 74.2588; South Canara, Kalkoppa forest, 74.2913, 74.2926: AMH.

Remarks—*Diorygma rufosporum* was earlier described by Patwardhan & Kulkarni (1979) as *Phaeographina rufospora* from the western Ghats of India. The species is found in semi-evergreen forests.

The species resembles *Phaeographina phlyctidiformis* Müll. Arg. (known from Manipur) with respect to the apothecia and ascospores but differs in chemistry. *P. phlyctidiformis* contains norstictic acid.

Diorygma saxicola B.O. Sharma & Makhija, **sp. nov.** Figure 6

MycoBank MB 513337

Similis Diorygma megasporum *sed habitus saxicola et excipulo divergentus differt.*

Etymology–From the Latin, *saxum,* rock, and the invariable suffix *-cola*, dweller, a reference to the species habitat on rock.

Holotypus: India, Meghalaya, Wiloe, 30.10.1977, *P.G. Patwardhan & M.B. Nagarkar*, 77.1095:AMH

Thallus saxicolous, greenish to pale gray, rough, uneven, cracked, warty; pseudocortex indistinct, very thin; algal layer 40–50 µm thick; medulla compact, studded with crystals. Ascocarps concolorous, numerous, curved, short, more or less flexuous, round to elongate, simple to branched, very closely arranged, immersed to slightly emergent. Disc narrow to broad, 0.2–0.3 mm broad. Exciple divergent, non-carbonized, poorly developed, yellowish brown laterally and basally, 2–3 indistinct striate at the apical region. Epithecium indistinct, brown, 7–10 µm thick. Hymenium hyaline, 126–210 µm tall, I+ blue violet laterally, not inspersed. Asci 1–6-spored. Ascospores hyaline, muriform, peripheral and central spore locules of equal size, 143–172 × 29–34 µm, I+ violet.

Chemistry—Stictic, constictic and norstictic (trace) acids present.

Remarks—The new species closely resembles *Diorygma megasporum* but *D. megasporum* has a convergent exciple and is corticolous. In contrast, *D. saxicola* has a divergent exciple and is saxicolous. So far no other species in the genus are known to be saxicolous except one collection mentioned in Kalb et al. (2004, p. 141). The species was collected in the evergreen forests of Meghalaya at a higher elevation of ca 1400 m.

Diorygma subalbatum (Patw. & Makhija) B.O. Sharma & Makhija**, comb. nov.**

MycoBank MB 513349 Figure 7

≡ *Helminthocarpon subalbatum* Patw. & Makhija, Biovigyanam 7: 128 (1981)

Holotypus–*India, Karnataka, Hebri, on Agumbe to Udipi road, in rain forest, elev. Approx. 200 m., A.V. Prabhu & M.B. Nagarkar, 77.500 (AMH) (!)*

Thallus ashy white, smooth, delimited by black hypothallus. Ascocarps whitish, numerous, straight to curved to flexuous, branched, 0.5–2.5 mm long, 0.3–0.6 mm broad, obtuse at the end, immersed or flushed with the thallus. Disc narrow to broad, white pruinose. Exciple convergent to divergent, non-carbonized, indistinctly striate. Epithecium indistinct, pale brown. Hymenium hyaline, 150–210 µm tall, I+ blue violet, not inspersed. Asci 1–8-spored. Ascospores hyaline, muriform, peripheral and central spore locules of equal size, 75–145 × 24–34 µm, I+ violet.

Chemistry—Norstictic, and stictic acids present.

Additional specimens examined—Karnataka, Hebri, *P.G. Patwardhan & M.B. Nagarkar*, 77.503, 77.546:AMH

Remarks—*Diorygma subalbatum* was described by Patwardhan & Makhija (1981) as *Helminthocarpon subalbatum* from the western Ghats of south India. This species is found in rain forest at lower elevation of ca. 200 m.

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